National Park Service
U.S. Department of the Interior

Natural Resource Stewardship and Science
Office of Education and Outreach

PARKScience
Integrating Research and Resource Management in the National Parks
ISSN 1090-9966

Volume 28, Number 1, Spring 2011

Published: 13 July 2011 (online) • http://www.nature.nps.gov/ParkScience/index.cfm?ArticleID=480&Page=1

Regional Fire Planning

Alternative futures for fire management under a changing climate

By Koren Nydick and Charisse Sydoriak

Abstract: The Alternative Fire Management Futures initiative is the first test of the Strategic Framework for Science in Support of Management in the Southern Sierra Nevada Ecoregion. The goal of this project is to develop critical information, processes, and tools to evaluate and create realistic and flexible fire management objectives based on plausible future environmental conditions in the Southern Sierra Nevada Ecoregion. The project is a collaboration among resource managers, fire managers, and scientists and uses a landscape approach. We combine existing tools (scenario planning, climate change vulnerability assessment, a climate change adaptation "toolbox," and structured decision making) to provide both qualitative strategic and spatially explicit operational management decision support. Results from this project will provide inputs to a National Park Service (NPS) resource stewardship strategy and NPS and U.S. Forest Service (USFS) fire management plans.

Key Words: climate change adaptation planning, fire management, Sierra Nevada

Introduction

The Southern Sierra Nevada Ecoregion contains extensive forests that depend upon periodic fire for their persistence (fig. 1). This includes fire-adapted giant sequoia trees, which not only depend on but also thrive with frequent fire. As a result of a century of fire exclusion, however, many otherwise protected landscapes have developed unnatural species compositions and forest structure with heavy fuel accumulations. In recent decades, warming temperatures and a shift toward earlier snowmelt have interacted with these changes in forest structure, resulting in more frequent lightning ignitions, more area burned, more frequent large wildfires, greater extent of stand-replacing high-severity fire, longer wildfire durations, and longer wildfire seasons (Westerling et al. 2006; Miller et al. 2008; Lutz et al. 2009). With projections of continued warming, fire activity and severity are expected to keep rising in the Sierra Nevada, increasing the risk of catastrophic wildland fire to human safety, property, communities, giant sequoias, and ecosystems. For example, four climate change scenarios forecast an increase in probability of large wildfires from 100% to 400% by 2070–2099 (Westerling and Bryant 2008).

Park managers increasingly recognize that climate change affects their abilities to appropriately manage fire and conserve valued ecosystem elements and services. Southern Sierra Nevada resource managers have decided to approach the challenge head-on to prepare for, reduce, and respond to these impacts. Sequoia and Kings Canyon National Parks, Sequoia National Forest, and Giant Sequoia National Monument are working together on a pilot project to develop the capacity to manage fire under a "new lens" and to revise fire management objectives, tools, and methods so that valued resources sensitive to climate change can be conserved at an appropriate scale. This is the first application of the Strategic Framework for Science in Support of Management in the Southern Sierra Nevada Ecoregion (NPS et al. 2009), described in the previous article. Importantly, the project seeks not only to understand which resources are most vulnerable to changes in climate, fire regimes, and other interacting stressors, but also to identify where these vulnerable resources are located and describe where and how fire management activities may need to vary in the future under different scenarios. Our specific project objectives are listed in table 1.

Sequoia and Kings Canyon National Parks, Sequoia National Forest, and Giant Sequoia National Monument are working together on a pilot project to develop the capacity to manage fire under a "new lens" and to revise fire management objectives, tools, and methods so that valued resources sensitive to climate change can be conserved at an appropriate scale.

This effort is an experiment reaching into uncharted territory, an iterative process that will be repeated and refined over time. Anticipated initial outputs include the development of a range of plausible future scenarios of climate, fire, and vegetation; spatially explicit resource vulnerability assessments; a decision support framework; and expertise and knowledge required to effectively and efficiently revise fire management objectives, prescriptions, and techniques.

The pilot project is an initiative of the newly formed Southern Sierra Conservation Cooperative (also described in the previous article). In addition, the project team will work collaboratively with the Southern Sierra Fire Science Integration Work Group. The information, tools, and management options developed as a result of this exercise will inform the five-year review of the parks' Fire and Fuels Management Plan scheduled for 2013, as well as upcoming U.S. Forest Service fire management plans.

Project approach

The alternative fire management futures project incorporates multiple complementary climate change adaptation approaches and tools. The National Park Service has been experimenting with a climate change scenario planning approach that overcomes the paralysis of uncertainty by using system drivers to create a range of plausible futures (Peterson et al. 2003; NPS 2011) (see article, page 26). Scenario planning is a strategic process in which managers and scientists describe divergent science-based future scenarios with the objective of revealing potential surprises and producing leaps of understanding. The goal is to make strategic decisions that will be sound for a range of plausible futures. Thus, scenario planning is a structured way of developing "what if" questions and analyses. Additionally, new guidance on climate change vulnerability assessments is now available, shedding light on methods to describe the exposure, sensitivity, and adaptive capacity elements of vulnerability (Glick et al. 2011). Also, the U.S. Forest Service has developed a toolbox approach that focuses on flexible, ecosystem-based management using an array of "no regrets," hedging, triage, proactive, and reactive tools to enhance resistance, resilience, response, and realignment of ecosystems (Millar et al. 2007; Peterson et al. 2011). Case studies of climate change preparedness planning using the scenario, vulnerability assessment, and toolbox approaches often describe strategic planning recommendations or species- or habitat-based vulnerability rankings, but they do not necessarily provide the on-the-ground spatial context sought by operational managers (but see Cole et al. 2011 for a spatially explicit treatment of the Joshua tree).

The alternative fire management futures exercise is a hybrid process that attempts to combine these approaches to address both strategic and operational preparedness. By combining approaches, our project team faces three key challenges: (1) linking the out-of-the box, big-picture thinking that scenario planning fosters with the spatial context that a geospatial vulnerability assessment provides, (2) communicating uncertainty in geospatial products and avoiding false precision and map misuse, and (3) translating climate change exposure and resource sensitivities into decision-support tools that will facilitate managers' abilities to increase resistance, resilience, and adaptive capacity of natural and human systems. Similar to the other approaches, this project has steps to orient, synthesize/analyze, consider management actions, and share lessons learned (see fig. 2). While most of the steps in the project are collaborative (purple arrows in fig. 2), it is important that certain elements fall into the domain of scientists and that others are the responsibility of managers (blue and red arrows, respectively, in fig. 2).

Scenario and vulnerability assessment workshops

A core team of agency scientists and managers, a university science cooperator, and an agency science coordinator to facilitate communication among them is engaged throughout the process. The first workshop was held on 20 January 2011 to gather this core team, provide background information, and review/revise the project objectives and process ("orient" in fig. 2). On 23–24 February we invited additional subject-matter science experts to a second workshop to help us kick off the explore/review and synthesize/assess steps. First, scientists shared knowledge about climate-fire-vegetation interactions. Then fire managers shared how fire is managed strategically and operationally and described challenges they face, especially in relation to climate change. On the second day, we began developing scenarios. The team identified climate water deficit (which integrates climate and water availability) and fire ignitions as two key uncertain yet important system drivers and used them to delineate four future scenarios. Smaller groups began refining the climate, fire, and vegetation responses for each scenario. To close the meeting, we discussed how to geospatially assess resource vulnerability. The small work groups continued refining scenarios via e-mail and the project leaders developed a conceptual plan and initial ideas for the vulnerability assessment.

The core team reconvened on 2–3 May to revisit the scenarios and produce a work plan for the vulnerability assessment. We found that the scenarios were not divergent enough and stepped back to parse out the important differences in hypothesized resource responses. We also embedded a second axis in the major axis-system. This secondary axis depicted the interannual variability versus seasonality of system drivers. We selected a plausible quadrant in the secondary set of axes to assign to each of the four original scenarios. This resulted in four "hypotheses of future change" scenarios titled "fire burnout," "mega mosaic," "fuel buildup," and "slow change." We added a fifth scenario called "landscape die-off" that could co-occur with any of the other scenarios. Because of the steep elevation gradient in the Sierra Nevada (about 500–14,495 ft [153–4,421 m] above sea level), we considered resource responses separately at low, mid, and high elevations. A small group has been assigned to continue developing the scenarios to ensure scientific robustness, internal cohesiveness, and divergence.

For the geospatial vulnerability assessment, we decided to take a climate envelope modeling approach (using downscaled data) to identify areas of hypothesized climate stability and stress for the major vegetation assemblages. We would then overlay modeled fire exposure, existing sensitivity of the landscape to fire, and various other indices of sensitivity for key valued resources. We will partially link the vulnerability assessment to the narrative scenarios by using four combinations similar to the narrative scenarios but formed by crossing two global circulation models and two greenhouse gas emissions scenarios. Using both the narrative scenarios and the vulnerability assessments, we plan to identify important thresholds of concern that may drive future management decisions. The next convening of the core team will be a resource consequences and management options workshop, scheduled for January 2012.

In phase two, the management focus, we will invite line officers and staff advisors to a March 2012 workshop to review scientific products, potential management options, and hypothesized consequences, and identify broad management strategies and on-the-ground operational practices. The last steps of the project are to develop and test a decision-support tool, possibly incorporating structured decision-making concepts, and to share lessons learned.

We hope that this project will contribute to the science (and art) of climate change adaptation planning by exploring and testing how to combine various existing approaches, such as scenario planning, vulnerability assessment, climate change adaptation toolbox, and structured decision making, to provide both shorter-, and longer-term (10–100 years) strategic and on-the-ground management decision-making support. Locally in the Southern Sierra Nevada, this project will provide critical information for an NPS resource stewardship strategy and both NPS and USFS fire management implementation plans.

Literature cited

Cole, K. L., K. Ironside, J. Eischeid, and G. Garfin. 2011. Past and ongoing shifts in Joshua tree support future modeled range contraction. Ecological Applications. Ecological Applications 21(1):137–149.

Glick, P., B. A. Stein, and N. A. Edelson, editors. 2011. Scanning the conservation horizon: A guide to climate change vulnerability assessment. National Wildlife Federation, Washington, D.C., USA.

Lutz, J. A., J. W. van Wagtendonk, A. E. Thode, J. D. Miller, and J. F. Franklin. 2009. Climate, lightning ignitions and fire severity in Yosemite National Park, California, USA. International Journal of Wildland Fire 18:765–774.

Millar, C. I., N. L. Stephenson, and S. L. Stephens. 2007. Climate change and forests of the future: Managing in the face of uncertainty. Ecological Applications 17:2145–2151.

Miller, J. D., H. D. D. Safford, M. Crimmons, and E. A. Thode. 2008. Quantitative evidence for increasing forest fire severity in the Sierra Nevada and southern Cascade Mountains, California and Nevada, USA. Ecosystems, doi: 10.1007/s10021-008-9201-9.

National Park Service, U.S. Geological Survey, and USDA Forest Service. 2009. A strategic framework for science in support of management in the Southern Sierra Nevada Ecoregion: A collaboratively developed approach. Southern Sierra Nevada Ecoregion, Three Rivers, California, USA. 24 pp. Available from http://www.nps.gov/seki/naturescience/sscc.htm.

NPS Climate Change Response Program Web site, http://www.nature.nps.gov/climatechange/adaptationplanning.cfm. Accessed 11 March 2011.

Peterson, G. D., G. S. Cumming, and S. R. Carpenter. 2003. Scenario planning: A tool for conservation in an uncertain world. Conservation Biology 17:358–366.

Peterson, D. L., C. I. Millar, L. A. Joyce, M. J. Furniss, J. E. Halofsky, R. P. Neilson, and T. L. Morelli. 2011. Responding to climate change on national forests: A guidebook for developing adaptation options. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Portland, Oregon, USA.

Westerling, A. L., and B. P. Bryant. 2008. Climate change and wildfire in California. Climate Change 87:S231–S249.

Westerling, A. L., H. G. Hidalgo, D. R. Cayan, and T. W. Swetnam. 2006. Warming and earlier spring snowmelt increase western U.S. forest wildfire activity. Science 313:940–943.

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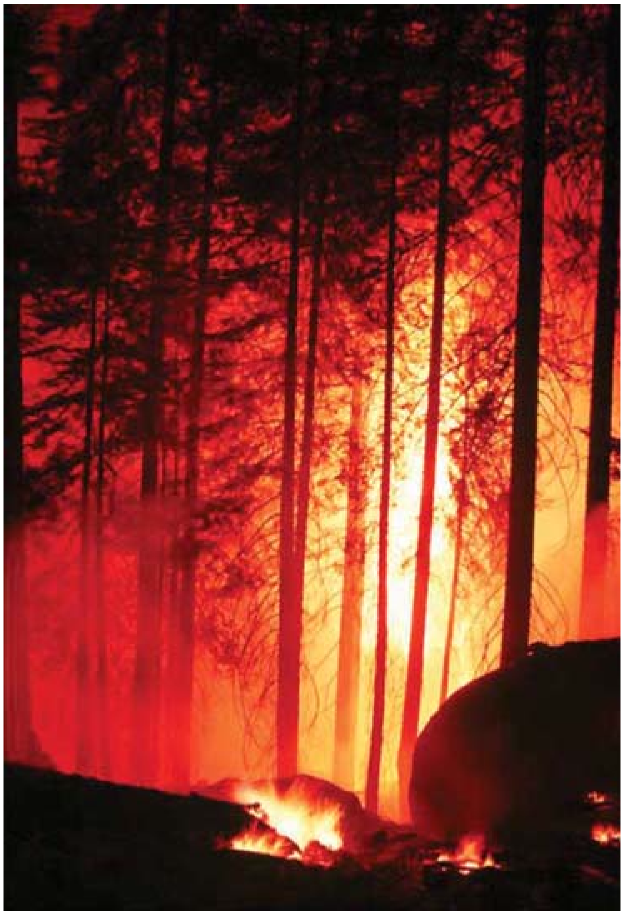

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Figure 1. Climate change adaptation strategies include prescribed burns like this fire in Sequoia National Park, which was also planned to learn about the effects of fire on hydrology and water chemistry.

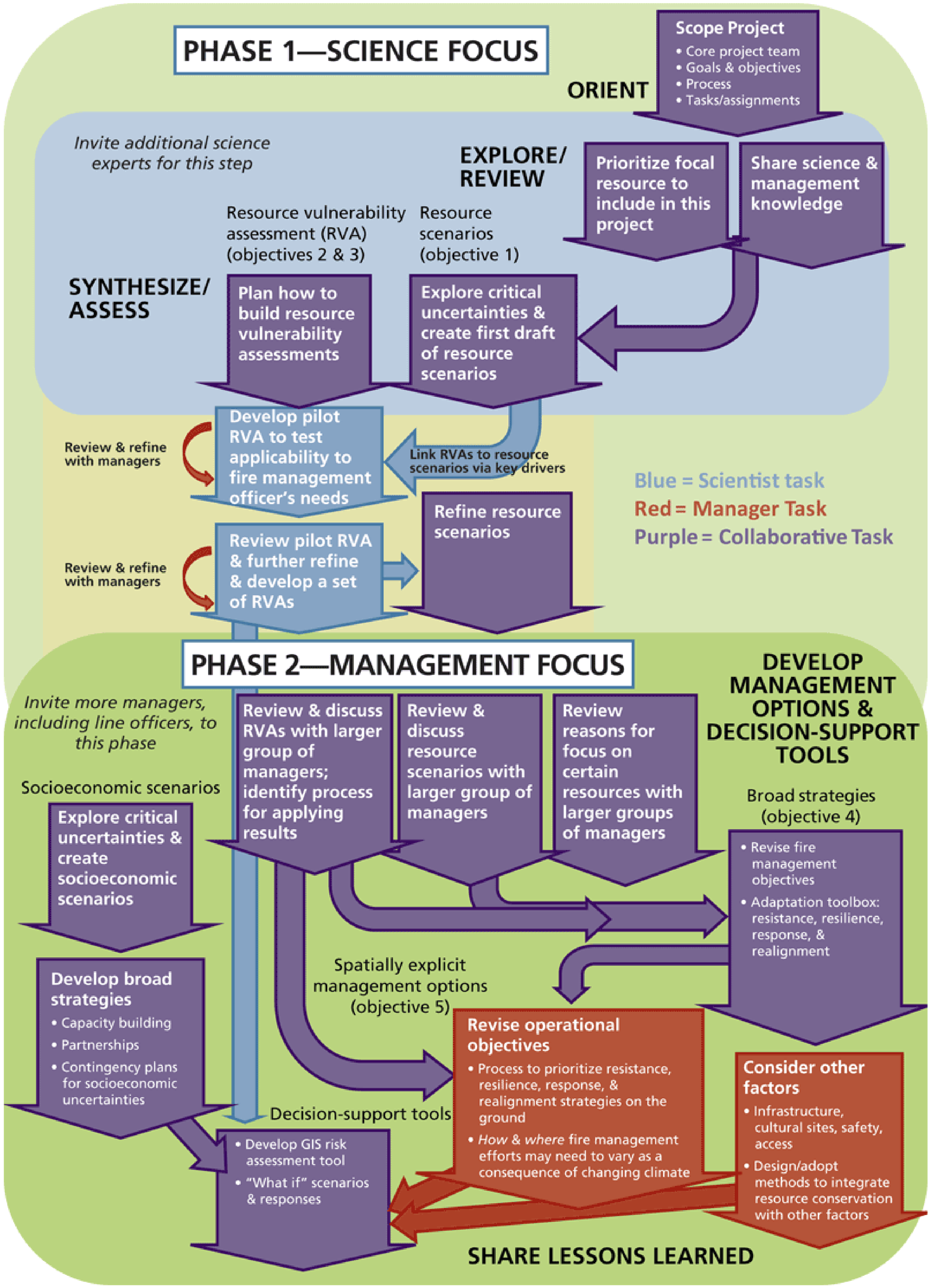

Figure 2. The fire management alternative futures project process is a collaborative approach that combines elements

of scenario planning, climate change vulnerability assessments, and the climate change adaptation toolbox.

Table 1. Project goal and objectives

Project Goal:	Develop the capacity to manage fire successfully under a â€œnew lensâ€ and to revise objectives, tools, and methods so that valued resources that are sensitive to climate change can be conserved at an appropriate scale.
Objective 1:	Define a range of plausible future scenarios with relevance to potential changes in climate, focal resources, and management policies.
Objective 2:	Identify which resources are likely to be most vulnerable to the interacting effects of changing climate, fire regimes, and other agents of change.
Objective 3:	Describe where biodiversity and other selected values are most likely to (a) remain stable without intervention, (b) survive if current fire management objectives and prescriptions are applied, and (c) suffer losses unless new fire management strategies are developed.
Objective 4:	Identify what fire management objectives and prescriptions (coping strategies) should be to enable the conservation of valued fire-dependent ecosystems and to protect fire-sensitive focal resources.
Objective 5:	Identify how and where fire management efforts may need to vary in the future as a consequence of changing climate.
Objective 6:	Share lessons learned from this project with the public and other federal land managers.

Park Science, Volume 28, Number 1, Spring 2011, ISSN 1090-9966
National Park Service, U.S. Department of the Interior
Natural Resource Program Center, Office of Education and Outreach
Lakewood, Colorado